(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number : **0 503 212 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication of patent specification : **27.12.95 Bulletin 95/52**

(51) Int. Cl.[6] : **H04L 12/40**, H04L 12/28

(21) Application number : **91810171.8**

(22) Date of filing : **15.03.91**

(54) **Communications network and method of regulating access to the busses in said network**

(43) Date of publication of application : **16.09.92 Bulletin 92/38**

(45) Publication of the grant of the patent : **27.12.95 Bulletin 95/52**

(84) Designated Contracting States : **DE FR GB**

(56) References cited :
EP-A- 0 158 364
EP-A- 0 393 293
GB-A- 2 162 722

(73) Proprietor : **INTERNATIONAL BUSINESS MACHINES CORPORATION**
Armonk, NY 10504 (US)

(72) Inventor : **Heinzmann, Peter Leander, Dr.**
Steingasse 4
CH-8175 Windlach (CH)
Inventor : **Müller, Johann Rudolf**
Erlenweg 7
CH-8135 Langnau am Albis (CH)
Inventor : **Nassehi, M. Mehdi, Dr.**
Aubrigstrasse 12
CH-8810 Horgen (CH)

(74) Representative : **Barth, Carl Otto et al**
International Business Machines Corp.
Zurich Research Laboratory
Intellectual Property Department
Säumerstrasse 4
CH-8803 Rüschlikon (CH)

EP 0 503 212 B1

Jouve, 18, rue Saint-Denis, 75001 PARIS

Description

The present invention relates to a communications network comprising two uni-directional and counterflowing busses, and to a method of regulating access to said busses.

Several kinds of network, are known in which plural nodes or stations gain access to a common transmission medium. Examples of such systems are single bus networks with collision detection, and token ring networks as well as token passing bus networks. Recently, networks providing another technique of multiple access to a common transmission medium have become of interest. These are systems comprising two parallel busses with counterflowing transmission of information on the two busses. Slots are released at regular intervals by headend stations, and these slots are used by the node stations for data transmission. Each node station has to request access to a slot by previously transmitting an access request in an Access Control Field of a passing slot. It keeps a count of access requests it has seen from other stations (located upstream in request transmission direction) before it raises an own access request, and lets as many free slots pass by (for use by the other stations) as the count indicated, before it occupies the next free slot for transmission of its own data.

Such systems were described e.g in a paper by R.M.Newman et al. entitled "The QPSX MAN", published in the IEEE Communications Magazine, Vol.26 No.4 (April 1988) pp.20-28; and in a Proposed Standard by IEEE 802.6 entitled "Distributed Queue Dual Bus (DQDB) Subnetwork of a Metropolitan Area Network (MAN)", Draft D14, July 13, 1990.

Though these known distributed queueing systems are well suited for networks comprising a limited number of stations, they have some disadvantages which become unacceptable and may render the system inefficient when the number of stations is raised to several hundred, and when the length of the transmission busses is in the order of several kilometers.

These disadvantages are in particular: An "unfairness" for some stations with respect to others, due to the fact that each station has to await a free access request field before it can transmit a request, so that stations located upstream (in request transmission direction) are preferred; and an impossibility to guarantee the availability of a sequence of consecutive slots for one station desiring to transmit the portions of a data packet without interruption.

In an article by S.B.Calo et al : "Poll Actuated Multiple Access Technique for Broadgathering Systems", IBM Technical Disclosure Bulletin, Vol.30, No.1 (June 1987) pp.72-75, a dual bus system is disclosed which has a plurality of stations connected between the busses. For controlling access to the busses, a pacer is provided at one end and a poller at the other end of the network. The pacing element partitions the time into contiguous slots which can be used by stations for data transmission. The polling element imposes a frame cycle structure by starting operation cycles. Each station can use only a limited number of slots in any cycle.

This method avoids the possibility that particular stations because of their topological situation can dominate the system (not leaving free slots for other stations). However, it has also disadvantages. As the allowed number of slots for each station is fixed or determined by central administration, situations may often occur that in a cycle a heavily active station cannot transmit as many slots as required, whereas momentarily silent stations will not use any slots of a cycle. This will result in a non-optimum utilization of the transmission network.

An access scheme for Gbit/s LAN and MAN bus systems, offering high throughput efficiency and fairness independent of the network speed or distance, is known from EP-0 393 293 (IBM). This scheme is referred to as Cyclic-Reservation Multiple- Access (CRMA). According to this scheme nodes reserve consecutive slots of a cycle for transmitting their packets, thus facilitating packet reassembly.

In CRMA each slot is productively used only for a portion of its passage along the bus, i.e. between the source node and the destination node. A modification to CRMA, called order-pad-passing or Cyclic-Reservation Multiple-Access with Slot-Reuse (CRMA/SR), is known from the not prepublished EP-application EP-A-0451426 (IBM). The invention according to said EP-application allows reuse of slots after they have reached their destinations.

This is achieved by gathering more detailed control information. Order pads are issued at each headend unit in the network, and each node is allowed to reset the "requested length" parameter in the passing order pads, if all requested time slots have reached their destination before they arrive at the node in question.

The technique for cyclic-reservation multiple access (CRMA) with slot reuse, proposed in EP-application EP-A-00451426 allows for significant increase in network capacity and reduced access delay under high load without giving up the basic CRMA advantages. This is achieved by introducing more intelligence in the order pad passing process, making use of the fact that slots which have reached their destinations at a certain node could be overwritten i.e., reused by other (downstream) nodes. For that purpose each node is allowed to reset the "requested length" parameter of the order pad to zero, whenever it is guaranteed that all requested slots (i.e. the segment payloads they contain) will have reached their destination upon arrival at this node. Hence, the reservation process can restart as if the order pad was issued by a headend, leading to an overall cycle length which is much shorter than in basic CRMA, i.e. the capacity in-

creases and the access delay is reduced.

In order to decide whether the slots will have reached their destinations, "node labels" which indicate the node positions along the bus must be introduced and some information about the destinations of the requested slots must be included in the order pad command. Furthermore, an indication about the reuse possibility in the data transmission process must be added to the Local Reservation Queues (to be explained later in more detail in connection with Fig.7). The Global Reservation Queue is not changed.

The order pad command for CRMA with slot reuse (CRMA/SR) contains now three parameters which are processed at the nodes. The "Requested Length" (REQ-LEN) parameter is similar to the same parameter in basic CRMA, except that it contains the accumulated number of ordered slots since its last reset to zero. The "Requested Maximum" (REQ-MAX) parameter saves the absolute maximum of the Requested Length within that cycle. It is initially set to zero and updated by each node whenever the accumulated Requested Length is larger than the current value of Requested Maximum. The "Destination Maximum" (DST-MAX) holds the node label of the most downstream destination of the already requested slots.

However, CRMA/SR is efficient only in situations with localized traffic. A single request for transmission from the first to the last node of the bus, e.g. a broadcast message, inhibits the reuse of any slots in the corresponding cycle.

Adaptive polling or probing, which is disclosed in J. F. Hayes, "An adaptive technique for local distribution," IEEE Trans. Commun., Vol.COM-26, Aug. 1978 is a polling scheme based on the tree-search algorithm. More specifically, a central controller polls the nodes for packets according to a round-robin discipline. In order to minimize the polling overhead, groups of nodes are asked if any of them has a packet. In a given round, first the controller asks all nodes. If there is a positive response, the nodes are partitioned into two subgroups according to the prefix of their binary labels. The procedure is repeated for each subgroup until the nodes which have a packet are identified.

The method according to the present invention is termed Scheduled Cyclic-Reservation Multiple-Access (S-CRMA).

The proposed partitioning for S-CRMA is significantly different from the partitioning scheme in the adaptive polling. First, the adaptive polling partitioning is based on addresses of the source nodes only, while in S-CRMA it is based on both source and destination addresses. Secondly, in S-CRMA the partitioning does not require a response from the nodes.

The network and method according to the present invention achieves more efficient slot usage under arbitrary traffic patterns. It requires only minor modifications in the CRMA protocol. There is no information about upstream nodes required, so that the reservations for one bus can be placed on the opposite bus, which gives better delay performance. It provides slot reuse, requiring just one additional parameter in the reservation command that indicates the maximum number of requested slots for that cycle.

The above advantages are achieved with a communications network as claimed in claim 1, and with a method of regulating access to the busses of said network, as claimed in claim 6. Preferred embodiments of the invention are brought out in the dependent claims.

Below a detailed description of the cycle structure, the reservation process and of a preferred embodiment of the invention will be given with reference to the drawings, in which

Figure 1 shows the network layout,

Figure 2 shows the frame segmentation scheme,

Figure 3 is an illustration of the slot format,

Figure 4 illustrates the S-CRMA command format,

Figure 5 shows the partitioning of the data over subcycles, and

Figure 6 shows the scheduling according to the invention for a specific traffic pattern.

The network 1 and method according to the invention (S-CRMA), is an implementation of an access scheme for dual-bus networks where transmission is organized in time slots 6 grouped into cycles 9.

A headend unit 2 in the network issues Reserve commands (or request poll messages). The format of such commands is shown in figure 4.

Each slot 6 is subdivided providing a signalling channel 7 carrying commands, and an (independent) data channel 8 that is used to transmit the user data. A node or station 3 that wants to transmit user data, i.e. a frame, breaks up the frame into a number of fixed length segments and adds some segment header information. It then places a reservation for the required number of slots of a certain cycle on the signalling channel 7. When the reservation has been confirmed and the corresponding cycle has started, the node can utilize the requested number of slots for the transmission of its frame (see figure 2).

S-CRMA works on networks that have logically two buses 4, 5, denoted A-bus 4 and B-bus 5 and the nodes (or stations) transmit and receive on both buses. The A-bus is used if the destination is located downstream, otherwise the data is transmitted on the B-bus. The terms upstream and downstream will always be used in reference to the A-bus. The nodes 3 are labeled linearly from 0 to N-1. Label assignment takes place at network initialization and after configuration changes using a process similar to the one described in EP-application EP-A-0451426 (IBM), P.L.Heinzmann, H.R.Müller, M.M. Nassehi "Multiple-Access Control for a Communication System with Or-

der Pad Passing".

The first node (or station), in the following referred to as "Head", of each bus (node 0 for the A-bus and node N-1 for the B-bus) includes a Head function that may be activated, and when activated it will be referred to as being in Head-A state and Head-B state respectively. When the Heads are in Head-A or Head-B state they act as centralized points of control. They issue Reserve commands periodically, in which the nodes can request a number of slots of a cycle, and then place the accumulated requests into a Global Reservation Queue. In response to said reservations, cycles with the requested number of slots are created. The beginning and number of the cycle is identified by a Start command which is placed in the signalling part of the first slot of that cycle. Each node keeps track of its own reservations in a Local Reservation Queue, and utilizes the requested number of slots, when the corresponding cycle arrives.

There is a busy/empty and an arbitrated/unarbitrated indicator in each slot identifying the slot as being used or unused, and reserved or for free-use, respectively. Slots for free-use are issued when no requests are pending and can be accessed immediately, i.e., without previous reservation. The slot format and the S-CRMA commands are shown in figures 3 and 4. These slots are best suited for transmission of single-segment data, e.g. an ATM cell, since slot contiguity is not guaranteed.

Every node has a separate access machine for each bus and the access processes to the busses are independent. Therefore, in the following only access to the A-bus is described; that for the B-bus is completely symmetric.

CYCLE STRUCTURE

A super-cycle is defined as a group of p=n+1 (sub)cycles, with n being the smallest integer such that 2^n is greater or equal to the number of nodes N in the network. The (sub)cycles are numbered from 0 to C, where C is equal to the maximum supported cycle number, e.g., 255 with 8-bit cycle numbers. For example, with N =200 < = 2^8 nodes there is n=8, and a super-cycle consists of p=9 (sub)cycles. In particular, the kth super-cycle consists of the (sub)cycles with the numbers pk, pk+1, pk+2,....., pk+n and the ith (sub)cycle has the cycle number pk+i.

RESERVATION PROCESS

The heads periodically poll all nodes via Reserve commands which can be issued at either Head-A or Head-B. Each Reserve command is identified by a bus-indicator, a cycle-number, and a priority. It furthermore contains a cycle-length and a maximum-length parameter, which both can be modified by the nodes. As the Reserve commands for the A-bus pass the nodes on the B-bus, each node is allowed to make one reservation per super-cycle. Which (sub)cycle to choose is determined by a function of the source and destination labels of the packet to transmit. (This is in contrast CRMA and CRMA/SR, where every node is allowed to make a reservation in each cycle). We propose a scheduling which is based on the bit-wise exclusive-or of the source and the destination node labels. Each station is in order to achieve this provided with EX-OR logic 14. This scheduling leads to a binary partitioning of the nodes into groups containing half, a quarter, an eighths, etc., of all nodes of the bus. In particular reservation takes place according to the following rules:

1. A node uses the ith (sub)cycle, i.e. makes a reservation for a cycle with a number pk+i, if the bit-wise exclusive-or of the packet's source node label and destination node label has a prefix consisting of n-i zeros, followed by a one. The remaining bits are not considered.
2. All the multi-cast or broadcast packets are transmitted in the (sub)cycles with numbers pk, namely the first cycles of the supercycles.

In case of multiframe transmission, e.g. when many ATM cells with different destinations have to be transmitted, presorting of the packets by destination labels is recommended. When a node places a reservation for the ith (sub)cycle, it either overwrites or augments the cycle-length parameter in a reservation field 15 (figure 4) by the number of requested slots, according to the following rule:

A node overwrites the cycle-length parameter of the ith (sub)cycle if its label in binary representation ends with i zeros. All other nodes just augment the cycle-length parameter by the number of requested slots.

By this procedure a node is defined where reuse starts, i.e. a node where all arriving slots have already delivered their data to the respective destinations and can be reused, so that reservation can start anew (except for keeping the previous max. reservation).

The maximum-length parameter is only changed if the cycle-length value becomes larger. When the Reserve command returns to the head, its maximum-length parameter indicates the total number of slots required by the nodes for the corresponding (sub)cycle, i.e. the total number of slots necessary and sufficient for satisfying all reservations. The total number of slots requested, i.e. the sum of the requested number of slots may be higher than the necessary number. The head then enters a reservation, containing the cycle-number and maximum-length, into the Global Reservation Queue for the corresponding priority, and confirms the requests by issuing a Confirm command. If the requests cannot be handled, a back-pressure mechanism is initiated. The queues are served by priority and according to a FIFO discipline.

DATA TRANSMISSION PROCESS

The headend unit 2 serves every reservation by creating a cycle 9 with the requested number of empty reserved slots 6. The first slot contains a Start command in the signaling field 7, that indicates the cycle-number. After observing a Start command, each node checks if there is an entry in its local reservation queue that matches with the cycle-number. If there is an entry for this ith (sub)cycle, the node uses the slots according to a function of its node label and of the (sub)cycle number:

1. If the node's label in binary representation ends with i zeros (indicating "start-of-reuse"), slots are used directly after the Start command and all remaining slots of the cycle are set to "empty" (i.e. they can be reused by downstream nodes).
2. If the node's label in binary representation does not end with i zeros, empty slots are used after the last "busy" slot of this cycle.

The binary partitioning for a network with N=8 nodes is depicted by figure 5, which shows the source and destination labels and the resulting EXOR-patterns, together with the (sub)cycle numbers of the kth super-cycle. Since there are not more than 2^3 nodes, we need n=3 bits for the node labels, and there are p=n+1=4 (sub)cycles per super-cycle.

Transmission from source nodes to destination nodes with higher labels take place on the A-bus, as illustrated in the upper-right triangle of the matrix. The B-bus transmission rules are given in the lower-left triangle. Figure 5 shows that the source node with label 000 always uses the A-bus. If it wants to transmit to node 001 it must make a reservation for a 1st (sub)cycle, i.e. for cycles with numbers 4k+1. For transmissions to the two nodes 010 and 011 2nd (sub)cycles, i.e. cycles with cycle 4k+2 must be used. The nodes 100,101,110, and 111, are reached in 3rd (sub)cycles, i.e. in cycles with numbers 4k+3.

The scheduling for a specific traffic pattern is illustrated in figure 6. Here, there are 6 slots to be transmitted from node 0 to 2, 2 slots from 1 to 3, 5 slots from 2 to 3, etc., as indicated by the arrows on top of the nodes. The horizontal arrows under the nodes indicate which transmissions are allowed in which (sub)cycles, e.g.,the 5 slots from 2 to 3 must be transmitted in (sub)cycle 1. The transmission of the 6, 2, 4, and 7 slots to the nodes 2,3, and 7 must take place in (sub)cycle 2.

With the given traffic pattern, (sub)cycle 1 will be 9 slots long, (sub)cycle 2 will be 11 slots long, and (sub)cycle 3 will be 7 slots long. This leads to a total length of the S-CRMA super-cycle of 27 slots. The same traffic pattern leads to 40 and 20 slots, in CRMA and CRMA/SR, respectively. Note, although CRMA/SR gives a shorter cycle here, it would not be effective if there was just one broadcast message.

In S-CRMA a node can determine in which (sub)cycle it has to transmit a packet, by simply processing its own source and destination labels. There is no need to include the maximum-destination-label in the reservation command, like in CRMA/SR. Furthermore, the nodes do not need to keep track of a "reuse flag" and a node does not need information about other nodes' transmissions in order to decide if reuse is possible or not. Consequently, S-CRMA allows the reservations for a given bus to be made on the opposite bus, which improves delay performance. S-CRMA is not as adaptive as CRMA/SR, but it is simpler and it is effective for arbitrary traffic patterns.

In pure CRMA the average cycle length grows linearly with the number of nodes (for equally distributed traffic). In S-CRMA the corresponding (super-)cycle length seems to be a logarithmic function of the number of nodes.

Claims

1. A communications network (1) comprising two unidirectional counterflowing transmission busses (4, 5), a plurality of stations (3) each connected to both busses and each station being identified by a label, and at least one headend unit (2) for generating time slots (6) on said busses (4,5), in which network each headend unit (2) comprises

means for regularly releasing request poll messages, each identified by a cycle number, and containing at least one reservation field (11; 15),
means for issuing time slots (6) in numbered cycles, said slots being provided for transmitting data,
a global reservation (12) queue for storing accumulated access requests from the nodes,
and in which network each station (3) comprises
a local reservation queue (13) for storing a value indicative of a number of locally requested slots and the number of the cycle for which the slots are requested, and wherein
each station is provided with means for requesting slot access by amending the contents of said reservation field (11; 15) in a passing request poll message, and for keeping a record of pending access requests;
characterized by

means (14) in each station for logically combining by means of a predetermined logical function, a source station label and a destination station label, for data to be transmitted,

means for deriving a first control number from the source station label and destination station label combination, such first control number corresponding to a particular cycle number; and

means in each station for identifying

whether a passing request poll message carries a cycle number corresponding to said first control number, and upon matching, for amending the reservation field of said request poll message to reflect the number of requested slots for data to be transmitted.

2. Network as claimed in claim 1, wherein each request poll message contains a field (15) for a length indicator representing the accumulated number of slots requested for the respective cycle, and wherein each station further comprises

means for deriving a second control number from its own node label, and comparing the cycle number of a request poll message to be used for requesting slots, with said second control number, to obtain a binary control value; and

means for requesting access to the transmission medium, in dependence of said binary control value, either by

augmenting the length indicator in said request poll message by the number of slots required for transmitting said data, or

by overwriting the length indicator by the number of slots required for transmitting said message, and marking the respective station as starting station for slot reuse in the respective cycle.

3. Network as claimed in claim 1 or 2, comprising means in the headend unit for inserting in the first slot of a cycle, the number of that cycle and an indicator for the start of the cycle.

4. Network as claimed in clan 3 comprising means in each station for sensing said start indicator in a passing time slot, and in response to the presence of such indicator, checking in the local reservation queue for an entry matching the cycle number.

5. Network as claimed in any of claims 1-4, wherein the logical combining means is an EX-OR logic (14), and the derived control number is taken as the number of '0' appearing before the first '1' of the result of the EX-ORing.

6. Method of regulating access to a unidirectional bus transmission system to which a plurality of stations identified by labels are connected, on which system data are transmitted in time slots which are released in numbered cycles by a headend unit, and in which said headend unit sends, for each of said cycles, a request poll message carrying the respective cycle number;
characterized by executing the following steps in any source station desiring to transmit data to a particular destination station:

logically combining by means of a predetermined logic function, for data to be transmitted, the source station label and the destination station label;

deriving a first control number from the logical combination of the source station label and the destination station label;

using, for requesting slots in which to transmit said data, only a request poll message carrying a cycle number which corresponds to said first control number; and

subsequently transmitting said data in slots of a cycle whose number corresponds to said first control number.

7. Method as claimed in claim 6, wherein each request poll message contains at least one field for a length indicator representing the accumulated number of slots requested for the respective cycle, and wherein the following steps are executed by a station which has data to transmit:

deriving a second control number from its own station label, and comparing the cycle number of a request poll message to be used for requesting slots, to said second control number, to obtain a binary control value; and

for requesting access to the transmission medium, in dependence of said binary control value, either

augmenting the length indicator in said request poll message by the number of slots required for transmitting said data, or

overwriting the length indicator by the number of slots required for transmitting said data, and marking the respective station as starting station for slot reuse in the respective cycle.

8. Method as claimed in claim 6 or 7, comprising performing the following steps:
in the headend unit, inserting in the first slot of a cycle, the number of that cycle and an indicator for the start of the cycle;
in each station, sensing said start indicator in a passing time slot, and in response to the presence of such indicator, checking in the local reservation queue for an entry matching the cycle number.

9. Method as claimed in any of claims 6-8, wherein each said poll message is issued as a reserve command comprising a plurality of fields transmitted in a plurality of consecutive slots.

10. Method as claimed in any of claims 6-9, wherein the step of logically combining labels in each node is effected by performing in each node an EX-ORing of the labels of the source station and the destination station respectively, and taking

said control number as the number of '0' appearing before the first '1' of the result of the EX-ORing of said labels.

Patentansprüche

1. Ein Übertragungsnetz (1), umfassend zwei einseitig gerichtete gegenläufige Übertragungsbusse (4, 5), eine Vielzahl von Stationen (3), die jeweils mit beiden Bussen verbunden sind, wobei jede Station durch einen Kennsatz gekennzeichnet ist, und mindestens eine Kopfstation (2) zur Erzeugung von Zeitschlitzen (6) auf den genannten Bussen (4, 5),
   wobei in dem genannten Netz jede Kopfstation (2) folgendes umfaßt:
   Mittel, um regelmäßig Anforderungsabfragemeldungen auszugeben, jede gekennzeichnet durch eine Zyklusnummer, und mindestens ein Reservierungsfeld (11; 15) enthaltend,
   Mittel zur Ausgabe von Zeitschlitzen (6) in numerierten Zyklen, wobei die genannten Schlitze zur Übertragung von Daten bereitgestellt werden,
   eine globale Reservierungswarteschlange (12) zum Speichern akkumulierter Zugangsanforderungen von den Knoten,
   und wobei in dem genannten Netz jede Station (3) folgendes umfaßt:
   eine lokale Reservierungswarteschlange (13) zum Speichern eines Werts, der eine Zahl von lokal angeforderten Schlitzen anzeigt, und die Nummer des Zyklus, für den die Schlitze angefordert wurden, und bei dem jede Station mit Mitteln ausgestattet ist, um den Zugang zu dem entsprechen Schlitz durch Ergänzen der Inhalte des genannte Reservierungsfelds (11; 15) in einer vorbeilaufenden Anforderungsabfragemeldung anzufordern, und um über die anstehenden Zugangsanforderungen Buch zu führen;
   gekennzeichnet durch
   Mittel (14) in jeder Station, um logisch mit Hilfe einer vorbestimmten logischen Funktion einen Ursprungsstations-Kennsatz und einen Zielstations-Kennsatz für die zu übertragenden Daten miteinander zu verknüpfen,
   Mittel, um aus der Verknüpfung des Ursprungsstations-Kennsatzes und des Zielstations-Kennsatzes eine erste Steuerungsnummer abzuleiten, wobei diese erste Steuerungsnummer einer bestimmten Zyklusnummer entspricht; und
   Mittel in jeder Station, um zu erkennen, ob eine vorbeilaufende Anforderungsabfragemeldung eine Zyklusnummer trägt, die der genannten ersten Steuerungsnummer entspricht, und um, bei Übereinstimmung, das Reservierungsfeld der genannten Anforderungsabfragemeldung zu ergänzen, so daß es die Anzahl der angeforderten Schlitze für die zu übertragenden Daten wiedergibt.

2. Netz nach Anspruch 1, bei dem jede Anforderungsabfragemeldung ein Feld (15) für einen Längenanzeiger enthält, der die akkumulierte Anzahl von Schlitzen darstellt, die für den betreffenden Zyklus angefordert wurden, und bei dem jede Station weiter folgendes umfaßt:
   Mittel, um von seinem eigenen Knotenkennsatz eine zweite Steuerungsnummer abzuleiten, und um die Zyklusnummer einer Anforderungsabfragemeldung, die zum Anfordern von Schlitzen verwendet wird, mit der genannten zweiten Steuerungsnummer zu vergleichen, um einen binären Steuerungswert zu erhalten; und
   Mittel, um den Zugang zu dem Übertragungsmedium anzufordern, abhängig von dem genannten binären Steuerungswert, entweder durch
   Vergrößern des Längenanzeigers in der genannten Anforderungsabfragemeldung um die Anzahl der Schlitze, die für die Übertragung der genannten Daten angefordert wurden, oder
   durch Überschreiben des Längenanzeigers durch die Anzahl der Schlitze, die zur Übertragung der genannten Meldung angefordert wurden, und Markieren der betreffenden Station als Startstation für die Wiederbelegung der Schlitze in dem betreffenden Zyklus.

3. Netz nach Anspruch 1 oder 2, Mittel in der Kopfstation umfassend, um in den ersten Schlitz in einem Zyklus die Nummer dieses Zyklus und einen Anzeiger für den Beginn des Zyklus einzufügen.

4. Netz nach Anspruch 3, in jeder Station Mittel umfassend, um den genannten Startanzeiger in einem vorbeifenden Zeitschlitz zu erkennen, und in Antwort auf das Vorhandensein dieses Anzeigers die lokale Reservierungswarteschlange auf einen zu der Zyklusnummer passenden Eintrag zu überprüfen.

5. Netz nach einem der Ansprüche 1 bis 4, bei dem das logische Verknüpfungsmittel eine EX-ODER-Logik (14) ist und die abgeleitete Steuerungsnummer als die Zahl "0" genommen wird, die vor der ersten "1" des Ergebnisses der EX-ODER-Operation erscheint.

6. Verfahren, um den Zugang zu einem Übertragungssystem mit einseitig gerichtetem Bus zu steuern, an den eine Vielzahl von Stationen angeschlossen ist, die durch Kennsätze gekennzeichnet sind, wobei in diesem System Daten in Zeitschlitzen übertragen werden, die in numerierten Zyklen von einer Kopfstation freigegeben

werden, und in dem die genannte Kopfstation für jeden der genannten Zyklen eine Anforderungsabfragemeldung sendet, die die betreffende Zyklusnummer trägt;
gekennzeichnet durch Ausführung der folgenden Schritte in jeder Ursprungsstation, die Daten an eine bestimmte Zielstation übertragen möchte:
logisches Verknüpfen mit Hilfe einer vorbestimmten logischen Funktion des Ursprungsstations-Kennsatzes und des Zielstations-Kennsatzes für die zu übertragenden Daten;
Ableiten einer ersten Steuerungsnummer von der logischen Verknüpfung des Ursprungsstations-Kennsatzes und des Zielstations-Kennsatzes;
zum Anfordern von Schlitzen, in denen die genannten Daten übertragen werden sollen, Verwenden nur einer Anforderungsabfragemeldung, die eine Zyklusnummer trägt, die der genannten ersten Steuerungsnummer entspricht; und
nachfolgendes Übertragen der genannten Daten in den Schlitzen eines Zyklus, dessen Nummer der genannten ersten Steuerungsnummer entspricht.

7. Verfahren nach Anspruch 6, bei dem jede Anforderungsabfragemeldung mindestens ein Feld für einen Längenanzeiger enthält, der die akkumulierte Anzahl von Schlitzen darstellt, die für den betreffenden Zyklus angefordert wurden, und bei dem die folgenden Schritte von einer Station ausgeführt werden, die Daten übertragen möchte:
Ableiten einer zweiten Steuerungsnummer von ihrem eigenen Stations-Kennsatz und Vergleichen der Zyklusnummer der Anforderungsabfragemeldung, die für das Anfordern von Schlitzen eingesetzt wird, mit der genannten zweiten Steuerungsnummer, um einen binären Steuerungswert zu erhalten; und
zum Anfordern des Zugangs zu dem Übertragungsmedium, abhängig von dem genannten binären Steuerwert, entweder Vergrößern des Längenanzeigers in der genannten Anforderungsabfragemeldung, um die Anzahl von Schlitzen, die zur Übertragung der genannten Daten angefordert wurden, oder
Überschreiben des Längenanzeigers durch die Anzahl von Schlitzen, die zur Übertragung der genannten Daten angefordert wurden, und Markieren der betreffenden Station als Startstation für das Wiederverwenden des Schlitzes in dem betreffenden Zyklus.

8. Verfahren nach Anspruch 6 oder 7, die Ausführung der folgenden Schritte umfassend:
in der Kopfstation, Einfügen in den ersten Schlitz eines Zyklus der Nummer dieses Zyklus und eines Anzeigers für den Start des Zyklus;
in jeder Station, Erkennen des genannten Startanzeigers in einem vorbeilaufenden Zeitschlitz und, in Antwort auf das Vorhandensein eines solchen Anzeigers, Prüfen der lokalen Reservierungswarteschlange in Hinblick auf einen mit der Zyklusnummer übereinstimmenden Eintrag.

9. Verfahren nach einem der Ansprüche 6 bis 8, bei dem jede genannte Abfragemeldung als ein Reservierungsbefehl ausgegeben wird, der eine Vielzahl von Feldern umfaßt, die in einer Vielzahl von aufeinanderfolgenden Schlitzen übertragen werden.

10. Verfahren nach einem der Ansprüche 6 bis 9, bei dem der Schritt des logischen Verknüpfens der Kennsätze in jedem Knoten ausgeführt wird, indem in jedem Knoten eine EX-ODER-Operation der Kennsätze der Ursprungsstation beziehungsweise der Zielstation ausgeführt wird, und die genannte Steuerungsnummer als die Zahl "0" genommen wird, die vor der ersten "1" des Ergebnisses der genannten EX-ODER-Operation mit den genannten Kennsätzen erscheint.

Revendications

1. Réseau de communications (1) comprenant deux bus de transmission à circulation contraire unidirectionnels (4, 5), une pluralité de stations (3) chacune étant reliée à la fois aux deux bus et chaque station étant identifiée par un repère et au moins une unité d'extrémité de tête (2) afin de générer des tranches de temps (6) sur lesdits bus (4, 5),
dans lequel réseau chaque unité d'extrémité de tête (2) comprend
un moyen pour libérer régulièrement des messages de scrutation de demande, chacun étant identifié par un numéro de cycle, et contenant au moins un champ de réservation (11, 15),
un moyen permettant d'émettre des tranches de temps (6) dans les cycles numérotés, lesdites tranches étant procurées pour la transmission des données,
une file d'attente de réservation globale (12) destinée à mémoriser les demandes d'accès accumulées provenant des noeuds,
et dans lequel réseau chaque station (3) comprend
une file d'attente de réservation locale (13) destinée à mémoriser une valeur indicative d'un certain nombre de tranches demandées localement et le numéro du cycle pour lequel les tranches sont demandées, et dans laquelle
chaque station est munie de moyens afin de demander l'accès à la tranche en modifiant le contenu dudit champ de réservation (11, 15) dans

une message de scrutation de demande passant, et afin de conserver un enregistrement des demandes d'accès en attente, caractérisée par
un moyen (14) dans chaque station destiné à combiner logiquement au moyen d'une fonction logique prédéterminée, un repère de station source et un repère de station de destination, pour les données à transmettre,
un moyen destiné à obtenir un premier numéro de contrôle à partir de la combinaison du repère de station source et du repère de station de destination, lequel premier numéro de contrôle correspond à un numéro de cycle particulier, et
un moyen dans chaque station destiné à identifier si un message de scrutation de demande passant achemine un numéro de cycle correspondant audit premier numéro de contrôle, et lorsqu'il y a correspondance, pour modifier le champ de réservation dudit message de scrutation de demande afin de représenter le nombre de tranches demandées pour les données à transmettre.

2. Réseau selon la revendication 1, dans lequel chaque message de scrutation de demande contient un champ (15) pour un indicateur de longueur représentant le nombre accumulé de tranches demandées pour le cycle respectif, et dans lequel chaque station comprend en outre
un moyen pour obtenir un second numéro de contrôle à partir de son propre repère de noeud et comparer le numéro de cycle d'un message de scrutation de demande à utiliser pour demander les tranches, avec ledit second numéro de contrôle afin d'obtenir une valeur de contrôle binaire, et
un moyen destiné à demander l'accès au support de transmission, suivant ladite valeur de commande binaire, soit
en allongeant l'indicateur de longueur dans ledit message de scrutation de demande avec le nombre de tranches requises pour transmettre lesdites données, soit
en écrasant l'indicateur de longueur avec le nombre de tranches requises pour transmettre ledit message et en repérant la station respective comme étant la station de départ pour la réutilisation de la tranche dans le cycle respectif.

3. Réseau selon la revendication 1 ou la revendication 2, comprenant un moyen dans l'unité d'extrémité de tête afin d'insérer dans la première tranche d'un cycle, le numéro de ce cycle et un indicateur du début du cycle.

4. Réseau selon la revendication 3 comprenant un moyen dans chaque station destiné à détecter ledit indicateur de début dans une tranche de temps passante, et en réponse à la présence d'un tel indicateur, vérifier dans la file d'attente de réservation locale l'existence d'une entrée correspondant au numéro de cycle.

5. Réseau selon l'une quelconque des revendications 1 à 4, dans lequel le moyen de combinaison logique est une logique de OU-EXCLUSIF (14) et le numéro de contrôle obtenu est pris comme étant le nombre de "0" apparaissant avant le premier "1" du résultat du traitement OU-EXCLUSIF.

6. Procédé de contrôle d'accès à un système de transmission à bus unidirectionnels auxquels sont reliées une pluralité de stations identifiées par des repères, sur lequel des données système sont transmises dans des tranches de temps qui sont libérées dans des cycles numérotés par une unité d'extrémité de tête, et dans lequel ladite unité d'extrémité de tête envoie, pour chacun desdits cycles, un message de scrutation de demande acheminant le numéro de cycle respectif,
caractérisé par l'exécution des étapes suivantes dans toutes stations source quelconque souhaitant transmettre des données vers une station de destination particulière :
la combinaison logique au moyen d'une fonction logique prédéterminée, pour les données à transmettre, du repère de station source, et du repère de station de destination,
l'obtention d'un premier numéro de contrôle à partir de la combinaison logique du repère de station source et du repère de station de destination,
l'utilisation, afin de demander des tranches dans lesquelles transmettre lesdites données, uniquement d'un message de scrutation de demande acheminant un numéro de cycle qui correspond audit premier numéro de commande, et
ensuite, la transmission desdites données dans les tranches d'un cycle dont le numéro correspond audit premier numéro de contrôle.

7. Procédé selon la revendication 6, dans lequel chaque message de scrutation de demande contient au moins un champ pour un indicateur de longueur représentant le nombre accumulé des tranches demandées pour le cycle respectif, et dans lequel les étapes suivantes sont exécutées par une station qui a des données à transmettre :
l'obtention d'un second numéro de commande à partir de son propre repère de station, et la comparaison du numéro de cycle d'un message de scrutation de demande à utiliser pour demander les tranches, avec ledit second numéro de commande, afin d'obtenir une valeur de contrôle binaire, et
afin de demander l'accès au support de transmission, suivant ladite valeur de commande binaire,

soit

ajouter à l'indicateur de longueur dans ledit message de scrutation de demande avec le nombre de tranches requises pour transmettre lesdites données, soit

écraser l'indicateur de longueur avec le nombre de tranches requises pour transmettre lesdites données, et repérer la station respective comme étant la station de début pour la réutilisation de la tranche dans le cycle respectif.

8. Procédé selon la revendication 6 ou la revendication 7, comprenant l'exécution des étapes suivantes :

dans l'unité d'extrémité de tête, l'insertion dans la première tranche d'un cycle, du numéro de ce cycle et d'un indicateur du début du cycle,

dans chaque station, la détection dudit indicateur de début dans une tranche de temps passante, et en réponse à la présence d'un tel indicateur, la vérification dans la file d'attente de réservation locale de l'existence d'une entrée correspondant au numéro de cycle.

9. Procédé selon l'une quelconque des revendications 6 à 8, dans lequel chaque dit message de scrutation est émis en tant que commande de réservation comprenant une pluralité de champs transmis dans une pluralité de tranches consécutives.

10. Procédé selon l'une quelconque des revendications 6 à 9, dans lequel l'étape consistant à combiner logiquement les repères dans chaque noeud est effectuée en réalisant dans chaque noeud un traitement OU-EXCLUSIF des repères de la station source et de la station de destination respectivement, et en prenant ledit numéro de commande comme étant le nombre de "0" apparaissant avant le premier "1" du résultat du traitement OU-EXCLUSIF desdits repères.

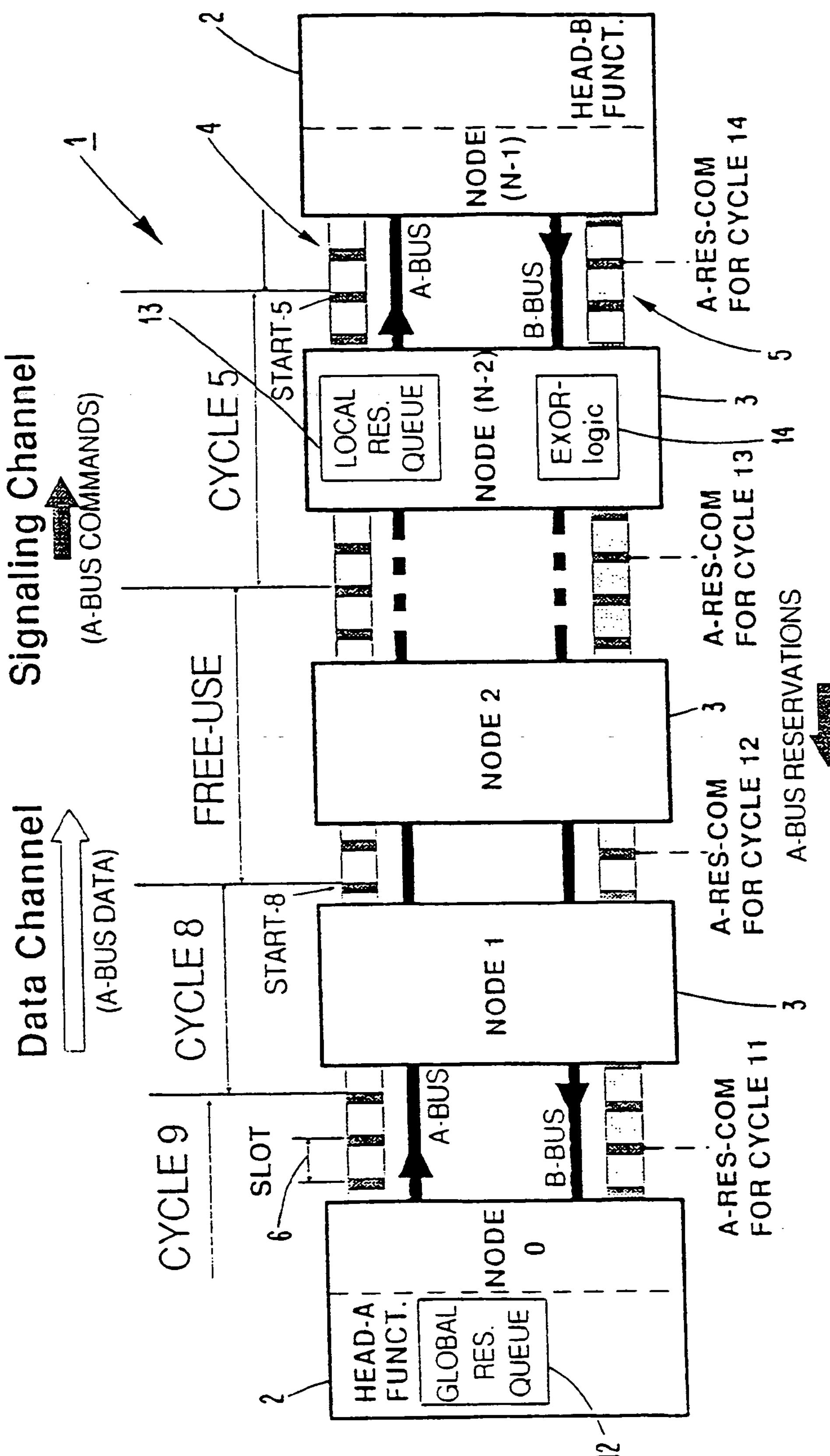
Signaling Channel
(A-BUS COMMANDS)
Data Channel
(A-BUS DATA)
CYCLE 9
CYCLE 8
FREE-USE
CYCLE 5
START-5
START-8
SLOT
HEAD-A FUNCT.
GLOBAL RES. QUEUE
NODE 0
NODE 1
NODE 2
NODE (N-2)
LOCAL RES. QUEUE
EXOR-logic
NODE (N-1)
HEAD-B FUNCT.
A-BUS
B-BUS
A-RES-COM FOR CYCLE 11
A-RES-COM FOR CYCLE 12
A-RES-COM FOR CYCLE 13
A-RES-COM FOR CYCLE 14
A-BUS RESERVATIONS
1
2
3
4
5
6
12
13
14

Figure 1

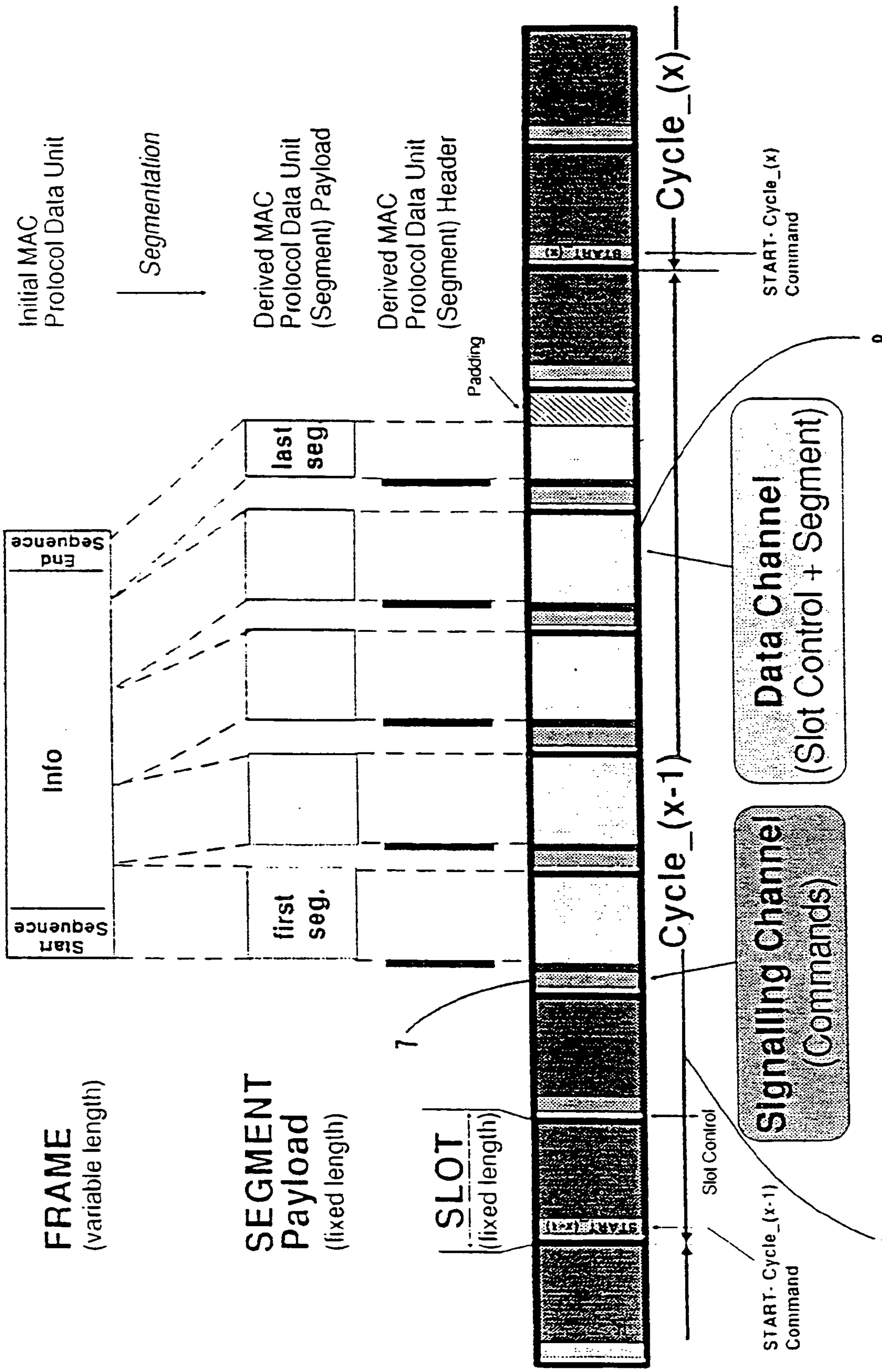
Initial MAC
Protocol Data Unit
Segmentation
Derived MAC
Protocol Data Unit
(Segment) Payload
Derived MAC
Protocol Data Unit
(Segment) Header
FRAME
(variable length)
Start
Sequence
Info
End
Sequence
SEGMENT
Payload
(fixed length)
first
seg.
last
seg
Padding
SLOT
(fixed length)
START (x-1)
START (x)
Slot Control
Cycle_(x-1)
Cycle_(x)
START- Cycle_(x-1)
Command
START- Cycle_(x)
Command
Signalling Channel
(Commands)
Data Channel
(Slot Control + Segment)
7
8
9

Figure 2

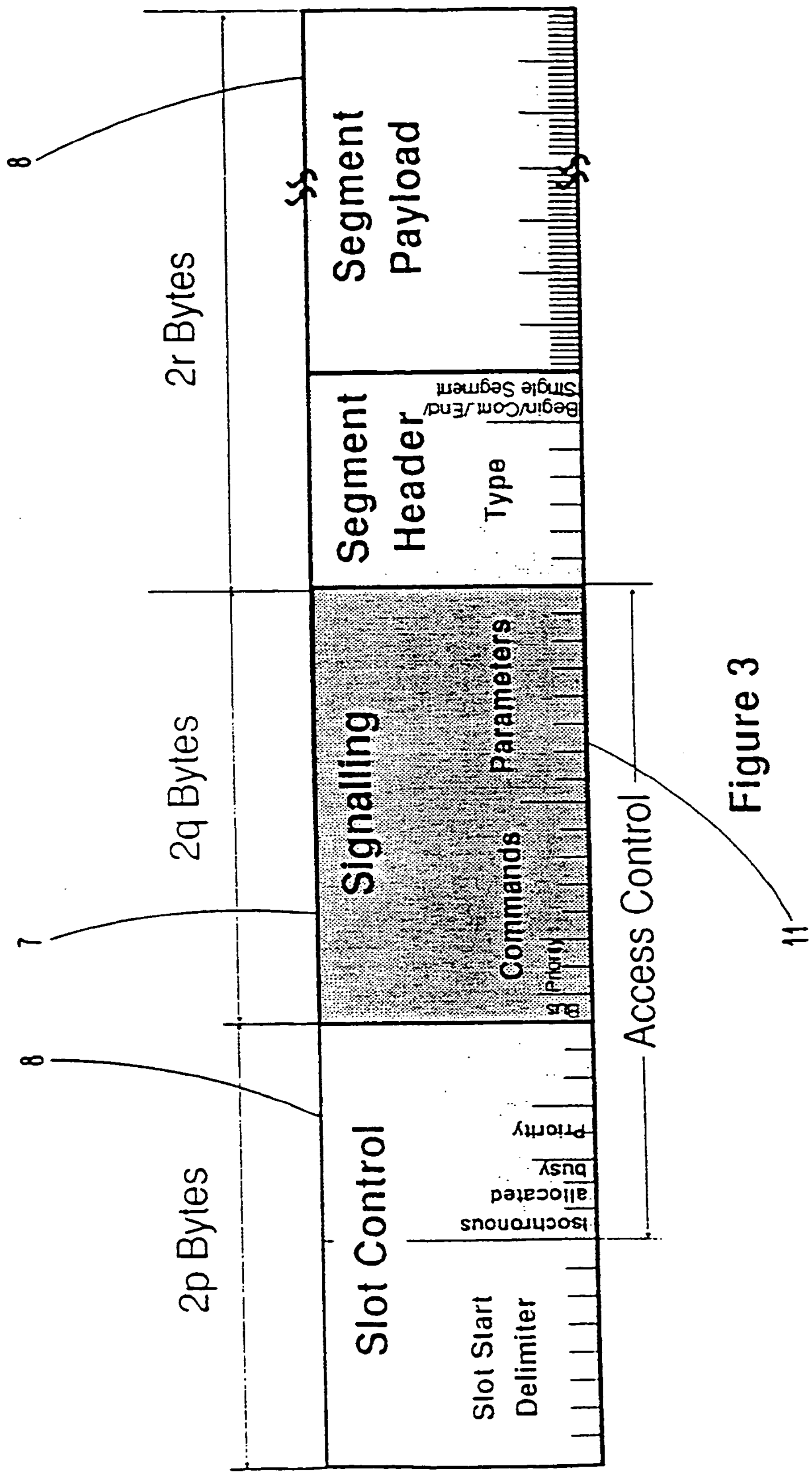
2p Bytes
2q Bytes
2r Bytes
8
7
8
Slot Control
Slot Start Delimiter
Isochronous
allocated
busy
Priority
Signalling
Bus
Priority
Commands
Parameters
Segment Header
Type
Begin/Cont./End/Single Segment
Segment Payload
Access Control
11

Figure 3

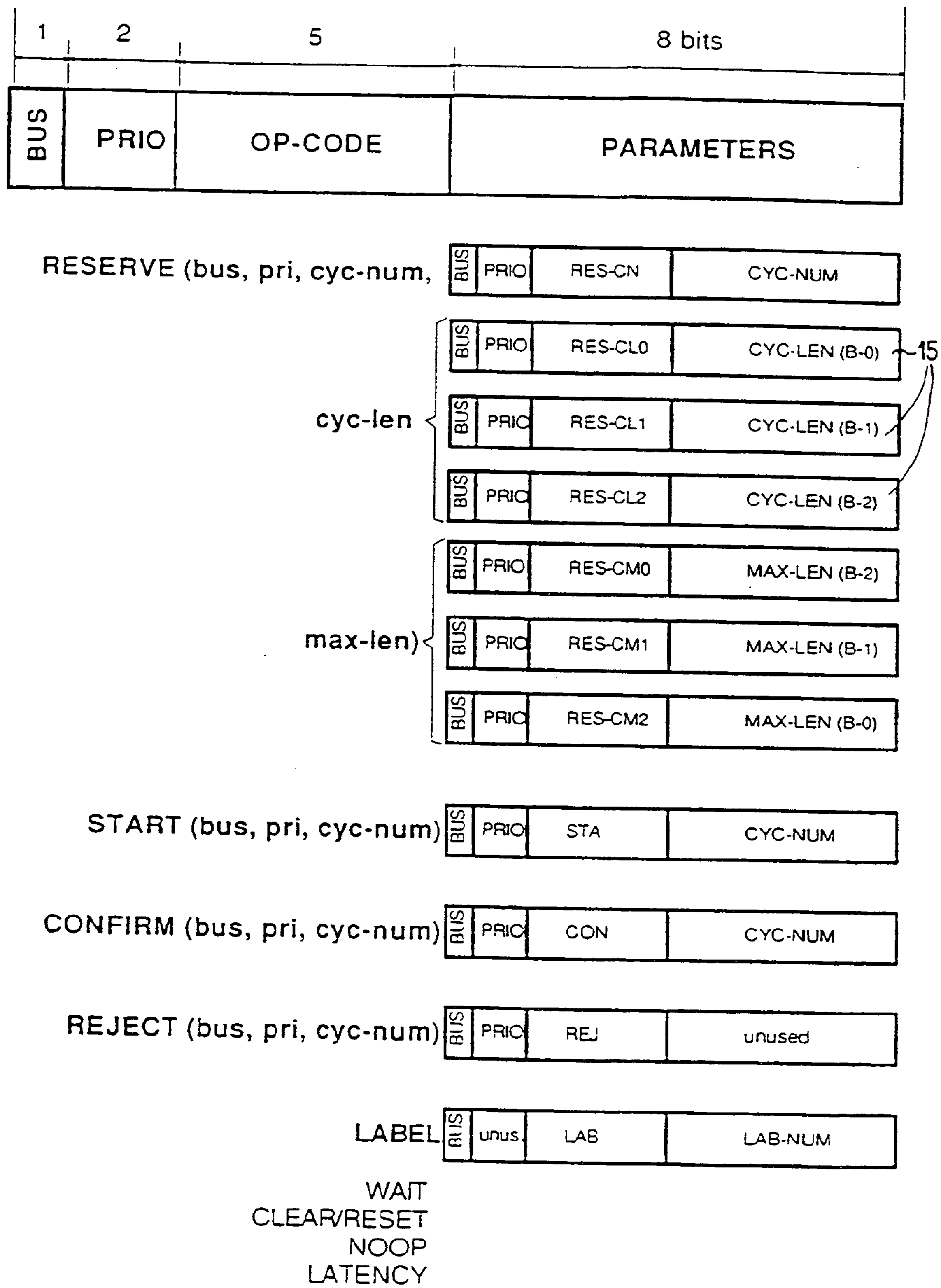
1
2
5
8 bits
BUS
PRIO
OP-CODE
PARAMETERS
RESERVE (bus, pri, cyc-num,
BUS PRIO RES-CN CYC-NUM
cyc-len
BUS PRIO RES-CL0 CYC-LEN (B-0)
15
BUS PRIO RES-CL1 CYC-LEN (B-1)
BUS PRIO RES-CL2 CYC-LEN (B-2)
max-len)
BUS PRIO RES-CM0 MAX-LEN (B-2)
BUS PRIO RES-CM1 MAX-LEN (B-1)
BUS PRIO RES-CM2 MAX-LEN (B-0)
START (bus, pri, cyc-num)
BUS PRIO STA CYC-NUM
CONFIRM (bus, pri, cyc-num)
BUS PRIO CON CYC-NUM
REJECT (bus, pri, cyc-num)
BUS PRIO REJ unused
LABEL
BUS unus. LAB LAB-NUM
WAIT
CLEAR/RESET
NOOP
LATENCY

Figure 4

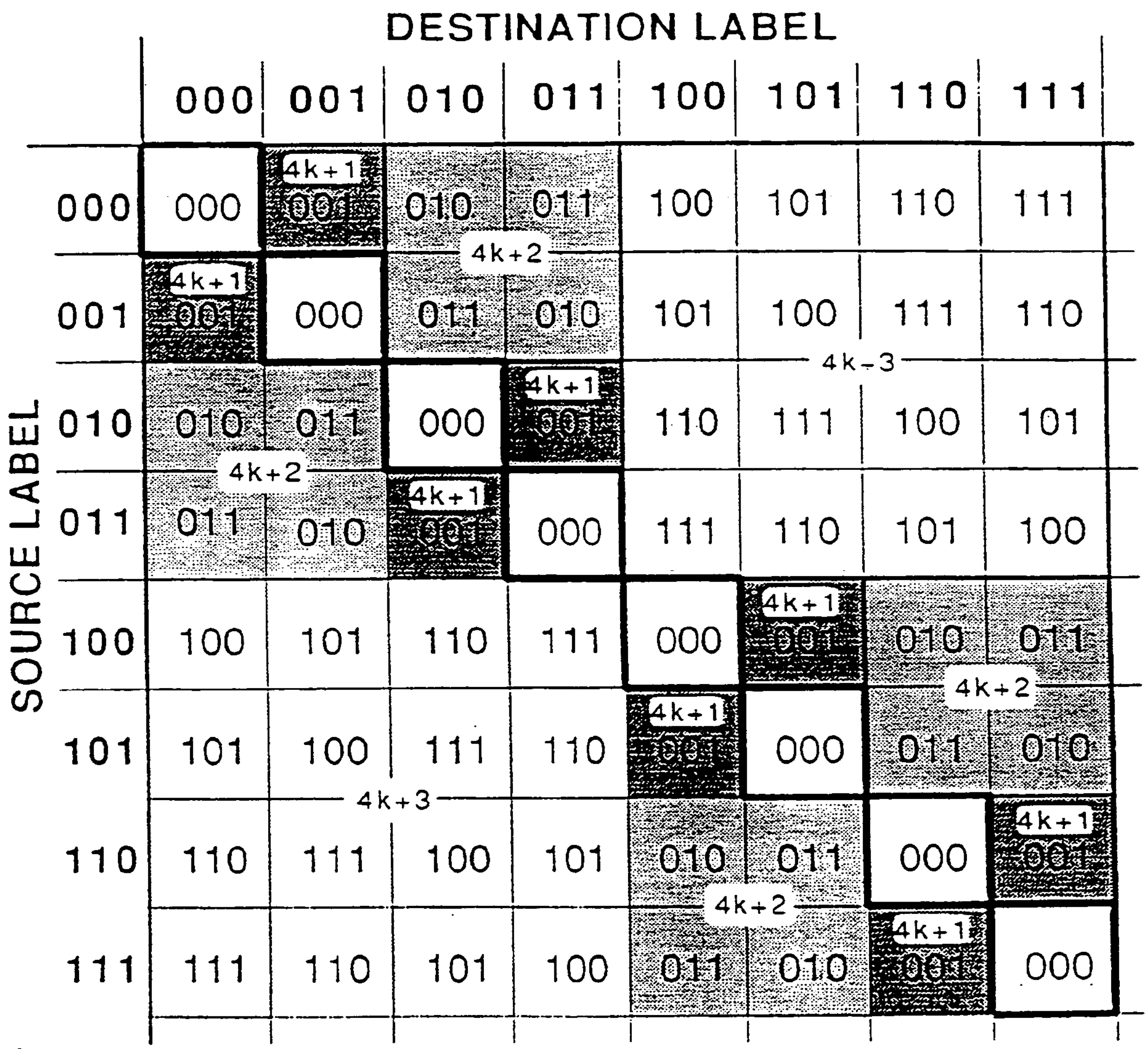
DESTINATION LABEL
SOURCE LABEL
000 001 010 011 100 101 110 111
000 000 4k+1 001 010 011 100 101 110 111
001 4k+1 001 000 011 010 101 100 111 110
010 010 011 000 4k+1 001 110 111 100 101
011 011 010 4k+1 001 000 111 110 101 100
100 100 101 110 111 000 4k+1 001 010 011
101 101 100 111 110 4k+1 001 000 011 010
110 110 111 100 101 010 011 000 4k+1 001
111 111 110 101 100 011 010 4k+1 001 000
4k+2
4k+2
4k+2
4k+2
4k+3
4k+3

Figure 5

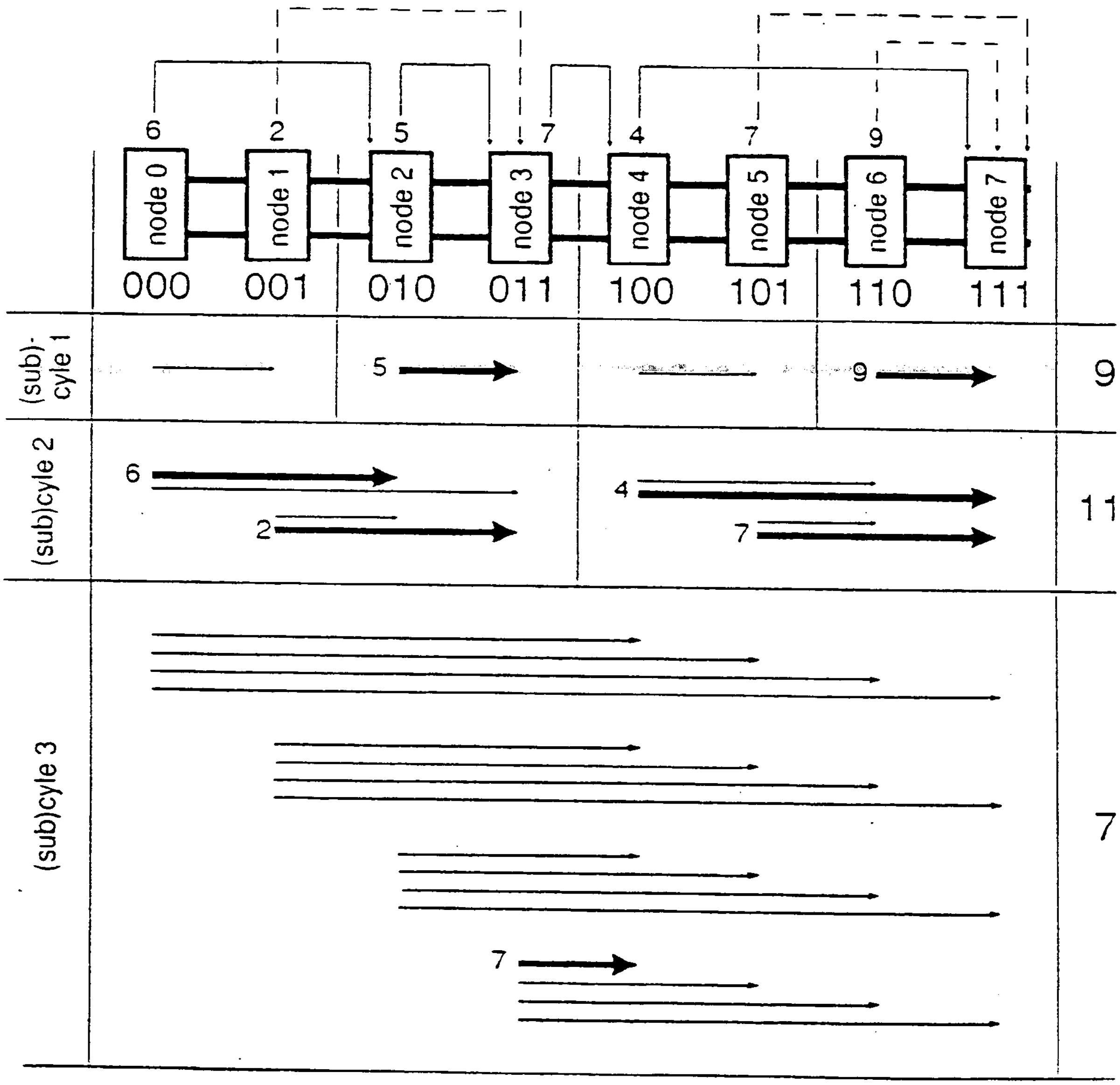
6
2
5
7
4
7
9
node 0
node 1
node 2
node 3
node 4
node 5
node 6
node 7
000
001
010
011
100
101
110
111
(sub)-cyle 1
5
9
9
(sub)cyle 2
6
2
4
7
11
(sub)cyle 3
7
7

Figure 6